LESSON 6 - LOW ASPECT BFM
(Problem Set 1 Due. Pick up Problem Set 2)
Today we will continue discussing close-in offensive and defensive BFM -- endgame maneuvers to kill and/or avoid being killed.

Reading:
>Shaw pp. 74-82, **pp. 82-97, pp. 23-31**
>11-F16 **Sec 4.7-4.8.7 (pp. 60-76)**
>Bretana pp. 71-80, pp. 85-94

Problems/Questions:
>**Finish** Problem Set 1

Objectives:
>6-1 Know how to properly enter a bandit's turn circle.
>6-2 Know when and how to properly separate.
>6-3 Understand what a guns jink is as when to use it in an aerial engagement.
>6-4 Understand what Flat Scissors, Rolling Scissors, and High/Low Stacks are and when to use them during an aerial engagement.
>6-5 Understand what a Defensive Spiral is and when to use it during an aerial engagement.

Last Time: Pursuit Types
                         Strategies
                         Maneuvers

Today: Entering and leaving a turning fight
                         Neutral Low-Aspect BFM
                                  High-Low Stacks
                                  Flat/Rolling Scissors
                         Last-Ditch Options
                                  Defensive Spiral
                                  Guns Jink

Equations: $r \propto V^2/G_r, \quad \omega \propto G_r/V, \quad P_s = (T-D)V/W$

Quiz

Last time we discussed pursuit curves and what they did for solving the three basic problems of BFM.

Review 3 problems of BFM
Review 3 pursuit curves

These pursuit curves are generally though of as same-plane maneuvers by beginner students of BFM. We then showed how getting out of the defender's plane could actually make these pursuit curves more effective.

The basic maneuvers used to modify the pursuit curves were the High and Low Yo-Yo

Review the effects and advantages of the yo-yos

We also showed that another problem of BFM is range *rate*, or closure. While decreasing the range is generally a good thing, you can get too much of a good thing and can go zipping right by your opponent, changing an offensive setup to a very defensive situation for yourself. We saw how a lag roll, or a roll around the defender's flight path, was a good way to solve this problem while still maintaining your energy relative to the bandit.

Today, we'll talk about how you got into that offensive position to begin with, and what to do if you find yourself losing the offense.

Describe flying along and all of a sudden being presented with a nice cooperative bandit who suddenly becomes aware of your presence and starts a turn.

What's he going to do? Most likely, he won't have a good enough feel for your range to try to run, so he'll probably turn to fight.
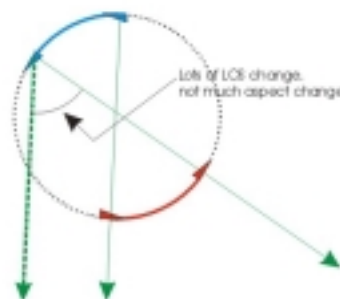
Will his turn be effective? Yes, but how effective depends on a lot of factors. For the time being, let's assume we're fighting a jet with pretty similar performance to ours.

The biggest factor on how effective the defender's initial turn will be is the attacker's range when he initiates the turn. If it's really close, the defender is very defensive, and the attacker may have already

Bandit turns with attacker well outside the turn circle

Not much line of sight change

Lots of aspect change
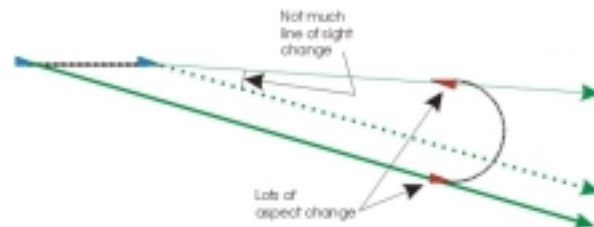
Bandit turns with attacker on the turn circle

Lots of LOS change, not much aspect change

begun the high-low yo-yo game trying to get into position for a shot.

The other extreme is if the range is quite large *compared to the turn diameter of the defender*. What happens if this is the case? For really large ranges, the defender can obviously turn all the way around to point at the attacker before the attacker solves his range problem. Now there's a huge angle problem to solve, and no one really has an advantage. This is a neutral setup.

These are the two extremes of approaching a bandit who eventually sees you: you can end up very offensive at best, or neutral at worst. There are a range of other results between these two, all based on when the defender realizes he's under attack, and all based on how close to his turn circle the attacker is when the defensive turn is initiated.

How do you know whether you're inside his turn circle when he starts the turn? A new concept called Line of Sight Rate (LOS) will help you determine this.

Imagine yourself walking across the crowded terrazzo. How do you know whether you're going to bump into someone else? Subconsciously, you all understand the concept of LOS.

Throw a pen at a cadet.

How did you know that pen was coming toward you? How did the rest of you know the pen was going to miss you? LOS. If you see the pen moving at a fixed angle with respect to you (whether you're still or moving), you're eventually going to hit it. It just appears to get bigger and bigger without changing angular position with respect to you. If it's going to miss, there's some small change in the angle that you can detect, and that's what we call LOS. If you detect any LOS, you're not going to hit. If there's none, you're on a collision course. Try it out on the terrazzo, or even with cars coming up to an intersection.
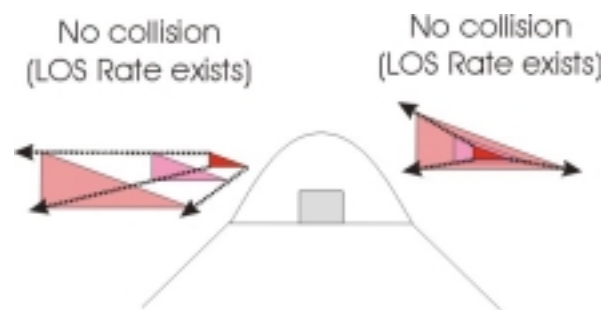
LOS, as discussed for collisions, are angular rates with respect to you. LOS, as important to turn circle discussions, are angular rates against a far-away background. If you're well outside the turn circle when the bandit starts his turn, you'll see a rather large, rapid change of aspect accompanied by very little change in the bandit's position against the background. He's basically turning around in place, from your point of view.

Show with small model plane

On the other hand, imagine yourself flying in a very offensive position. In this case, the defender's turn isn't producing a whole lot of aspect change for you, but his position across the background is changing very rapidly—about as rapidly as your turn rate.

Show with sticks

Again those are the two extremes. There are many intermediate cases. The key is to realize when you're at the defender's turn circle so you can begin your maneuvering. You've now solved most of the range problems, and now angle and pointing begin to become more important. In other words, as long as you arrive at the defender's turn circle in a reasonably offensive position, it's time to start working on your basic BFM maneuvers.

What happens if you find yourself losing the offensive? What if you need to leave the fight for some reason, perhaps fuel, perhaps you've run out of ordnance (a condition called "Winchester"). Once you've got a tiger by the tail, how do you let go? A good way to get out is called a separation maneuver. It's basically a HUGE low yo-yo. You take a big bid for the low vertical and try to cut way across the defender's turn circle. What is happening to your jet? Think about parameters that change for you during a low yo-yo. Going low and pulling less Gs allows you to accelerate as you cut across the defender's turn circle. You also build up significant aspect angles in a hurry.

Your goal in the separation maneuver is to keep the defender defensive as long as possible. As you pull back up to the defender's plane of motion, you need to get your nose out in lead and take a very short-range snapshot (a low probability of kill (P_k) gunshot with a high LOS rate). Right after this, you intentionally overshoot, reverse your direction of turn, and run like hell.

What's an overshoot? Any time you cross the defender's extended six o'clock, that's called an overshoot. Is that bad? Not necessarily. Think about lag roll. You cross his six, but are in control the whole time, still forcing the bandit to think defensively.

A bad overshoot, on the other hand, is one where you have a very high LOS rate as you cross the bandit's six. In this case, there's a very real possibility that the bandit could reverse the direction of his turn and become offensive, a move called a reversal (not only does the direction of the fight reverse, but so do your fortunes!). The reason you take a HUGE low yo-yo to separate is that you want to make the defender's angle problem as big as possible when you overshoot. You take the snapshot so he has to stay defensive, delaying the time when he can reverse his direction of turn to try to become offensive.

During the overshoot, the defender loses sight of you below his airplane. This is when you execute the turn reversal, get the nose slightly below the horizon, make sure you're in max AB, and unload to near zero-g. Why do you do all of these things? What's your goal? You already tried to make the bandit's angular problems as bad as possible, now you're trying to hurt his range problems.

The key to a good separation maneuver is applying the physics you know to maximize both of these problems so you can get out of range before he can turn around to pop you with a missile.

Let's talk about what happens if you fail to get sufficient angles, or if you end up in a fairly neutral position. A series of overshoots can easily occur, called a flat scissors. It generally occurs when you're maneuvering near the horizontal plane.

Show flat scissors with sticks.

The goal of a flat scissors is to go slower fastest. You want to be able to slow down faster than the bandit can so you can get behind him for a shot. The trick is that you need to keep your energy up high enough that you have sufficient maneuverability to point your nose for the shot when the opportunity comes. This means you're slowing down with the power up. How do you do that? Generally, flat scissors end up climbing.

As a defender, what is your goal, besides surviving? To make the attacker's job as hard as possible. If he's in a low yo-yo, how do you do this? You pull down into him. If he's in a high yo-yo, you pull up into him. Take away the advantage he's trying to gain. Many times, if you can get out of phase with him, you can overshoot him in the vertical. The result of this move is that now he's no longer offensive, and the fight often degrades to a series of vertical overshoots and a concomitant series of offense/defense changes called a rolling scissors.

Discuss the physics of rolling scissors

Show with sticks.
That's about all we've got time for today. Next lesson, be sure to bring a 3.5" disk, as we'll be applying many of the things we've learned so far to analyze the turn performance of a jet.

We'll discuss